AMENDMENTS TO THE CLAIMS

1. (Original) A method in a computing system for controlling an electroplating process in which a sequence of workpieces are electroplated with a material each in an electroplating cycle, such controlling including designating, for each electroplated workpiece, currents supplied to each of a plurality of electroplating anodes, comprising:

constructing a Jacobian sensitivity matrix characterizing the effects on plated material thickness at each of a plurality of workpiece positions of varying the currents supplied each of the plurality of anodes;

receiving a specification of target plating material thickness at each of the plurality of workpiece positions;

applying the Jacobian sensitivity matrix to make a first determination of how a baseline set of anode currents should be varied to produce the specified target plating material thicknesses rather than baseline plating material thicknesses indicated to result from the baseline set of anode currents;

generating an indication to conduct a first electroplating cycle with respect to a first workpiece using a designated set of anode currents produced by varying the baseline set of anode currents in accordance with the first determination;

receiving measured plating material thicknesses thickness at each of the plurality of workpiece positions of the first workpiece;

applying the Jacobian sensitivity matrix to make a second determination of how the set of anode currents designated for the first electroplating cycle should be varied to produce the specified target plating material thicknesses rather than measured plating material thicknesses of the first workpiece; and

generating an indication to conduct a second electroplating cycle with respect to a second workpiece using a designated set of anode currents produced by varying the set of anode currents designated for the first electroplating cycle in accordance with the second determination.

2. (Original) The method of claim 1, further comprising:

receiving measured plating material thicknesses at each of the plurality of workpiece positions from the second electroplating cycle;

determining that the measured plating material thicknesses from the second electroplating cycle are within a specified tolerance of the specified target plating material thicknesses; and

in response to the determination, generating one or more indications to conduct a plurality of further electroplating cycles using the set of anode currents designated for the second electroplating cycle.

3. (Original) The method of claim 1, further comprising:

receiving measured plating material thicknesses at each of the plurality of workpiece positions from the second electroplating cycle;

applying the Jacobian sensitivity matrix to make a third determination of how the set of anode currents designated for the second electroplating cycle should be varied to produce the specified target plating material thicknesses rather than measured plating material thicknesses of the second workpiece; and

generating an indication to conduct a third electroplating cycle using a designated set of anode currents produced by varying the set of anode currents designated for the second electroplating cycle in accordance with the second determination.

4. (Original) The method of claim 1, further comprising:

before the first electroplating cycle, receiving measured seed layer thicknesses of the first workpiece at each of the plurality of workpiece positions; and

before the second electroplating cycle, receiving measured seed layer thicknesses of the second workpiece at each of the plurality of workpiece positions,

and wherein the second determination made by applying the Jacobian sensitivity matrix is a determination of how the set of anode currents designated for the first

electroplating cycle should be varied to produce the specified target plating material thicknesses rather than measured plating material thicknesses of the first workpiece in light of the differences between the measured seed layer thicknesses of the first and second workpieces.

5. (Original) The method of claim 1 wherein the Jacobian sensitivity matrix is generated from a mathematical model of the electroplating process.

6. (Original) The method of claim 1 wherein the Jacobian sensitivity matrix is generated from data obtained by operating the electroplating process.

7. (Original) The method of claim 1 wherein the baseline plating material thicknesses are generated from data obtained by simulating operation of the electroplating process using a mathematical model of the electroplating process, the simulation using the baseline anode currents.

8. (Original) The method of claim 1 wherein the baseline plating material thicknesses are generated from data obtained by operating the electroplating process with the baseline anode currents.

9. (Currently Amended) A method in a computing system for providing closed-loop control of a process for applying a coating material to a series of workpieces to produce a coating layer of the coating material, comprising:

(a) receiving a coating profile specifying one or more attributes of the coating layer to be produced on the workpieces;

(b) designating a first set of coating parameters for use in coating a first workpiece;

(c) identifying a first set of discrepancies between attributes of the coating layer produced on the first workpiece using the first set of coating parameters and the attributes specified by the coating profile;

(d) determining a first set of modifications to the first set of coating parameters expected to reduce the identified first set of discrepancies;

(e) modifying the first set of coating parameters in accordance with the determined first set of modifications to produce a second set of coating parameters;

(f) designating the second set of coating parameters for use in coating a second workpiece; and

(g) repeating (c) – (f) for subsequent workpieces in the series until the identified set of discrepancies falls within a selected tolerance, wherein the process is performed in an electrolysis chamber having a plurality of anodes, and wherein at least a portion of the coating parameters are currents to transmit through identified anodes among the plurality of anodes-.

10. (Original) The method of claim 9, further comprising, after (g), designating the most recently-produced set of coating parameters for use in coating subsequent workpieces.

11. (Original) The method of claim 9 wherein each workpiece is a silicon wafer.

12. (Original) The method of claim 9 wherein the coating material is a conductor.

13. (Original) The method of claim 9 wherein the coating material is copper.

14. (Cancelled)

15. (Original) The method of claim 9 wherein at least a portion of the attributes of the coating layer to be produced on the workpieces specified by the coating profile are target thicknesses of the coating layer in selected regions on the workpiece.

16. (Original) The method of claim 15 wherein the discrepancies identified in (c) correspond to differences between thicknesses measured in the selected regions on the coated workpiece and the target thicknesses specified by the coating profile for the selected regions on the workpiece.

17. (Original) The method of claim 15, further comprising:

generating a set of predicted coating thicknesses in the selected regions on the first workpiece based upon the first set of coating parameters;

receiving an indication of thicknesses measured in the selected regions on the coated first workpiece;

computing a difference between the predicted coating thicknesses and the indicated measured thicknesses; and

subtracting the computed difference from the determined first set of modifications before using the first set of modifications to modify the first set of coating parameters.

18. (Currently Amended) ~~The method of claim 15~~ A method in a computing system for providing closed-loop control of a process for applying a coating material to a series of workpieces to produce a coating layer of the coating material, comprising:

(a) receiving a coating profile specifying one or more attributes of the coating layer to be produced on the workpieces;

(b) designating a first set of coating parameters for use in coating a first workpiece;

(c) identifying a first set of discrepancies between attributes of the coating layer produced on the first workpiece using the first set of coating parameters and the attributes specified by the coating profile;

(d) determining a first set of modifications to the first set of coating parameters expected to reduce the identified first set of discrepancies;

(e) modifying the first set of coating parameters in accordance with the determined first set of modifications to produce a second set of coating parameters;

(f) designating the second set of coating parameters for use in coating a second workpiece; and

(g) repeating (c) – (f) for subsequent workpieces in the series until the identified set of discrepancies falls within a selected tolerance,

wherein each of the workpieces bears a seed layer, the method further comprising:

for each the first and second workpieces, receiving an indication of seed layer thicknesses measured in the selected regions on the workpiece before the workpiece is coated; and

before designating the second set of coating parameters for use in coating a second workpiece, further adjusting the second set of coating parameters in to adjust for differences between the measured thicknesses of the first and second workpieces.

19. (Original) The method of claim 9 wherein the coating process is electrolytic deposition.

20. (Original) The method of claim 9 wherein the coating process is electrophoretic deposition.

21. (Original) The method of claim 9 wherein the coating process is chemical vapor deposition.

22. (Original) The method of claim 9 wherein the coating process is physical vapor deposition.

23. (Original) The method of claim 9 wherein the coating process is electron beam atomization.

24. (Currently Amended) ~~The method of claim 9~~ A method in a computing system for providing closed-loop control of a process for applying a coating material to a series of workpieces to produce a coating layer of the coating material, comprising:

(a) receiving a coating profile specifying one or more attributes of the coating layer to be produced on the workpieces;

(b) designating a first set of coating parameters for use in coating a first workpiece;

(c) identifying a first set of discrepancies between attributes of the coating layer produced on the first workpiece using the first set of coating parameters and the attributes specified by the coating profile;

(d) determining a first set of modifications to the first set of coating parameters expected to reduce the identified first set of discrepancies;

(e) modifying the first set of coating parameters in accordance with the determined first set of modifications to produce a second set of coating parameters;

(f) designating the second set of coating parameters for use in coating a second workpiece; and

(g) repeating (c) – (f) for subsequent workpieces in the series until the identified set of discrepancies falls within a selected tolerance,

wherein (d) utilizes a sensitivity matrix mapping changes in attributes to changes in coating parameters expected to produce those attribute changes.

25. (Original) A computer-readable medium whose contents cause a computing system to provide closed-loop control of a process for applying a coating material to a series of workpieces to produce a coating layer of the coating material by:

(a) receiving a coating profile specifying one or more attributes of the coating layer to be produced on the workpieces;

(b) designating a first set of coating parameters for use in coating a first workpiece;

(c) identifying a first set of discrepancies between attributes of the coating layer produced on the first workpiece using the first set of coating parameters and the attributes specified by the coating profile;

(d) determining a first set of modifications to the first set of coating parameters expected to reduce the identified first set of discrepancies;

(e) modifying the first set of coating parameters in accordance with the determined first set of modifications to produce a second set of coating parameters; and

(f) designating the second set of coating parameters for use in coating a second workpiece.

26. (Original) The computer-readable medium of claim 25, further comprising repeating (c) – (f) for subsequent workpieces in the series until the identified set of discrepancies falls within a selected tolerance.

27. (Original) A method in a computing system for automatically configuring parameters controlling operation of a deposition chamber to deposit material on each of a sequence of at least two wafers to improve conformity with a specified deposition pattern, comprising:

for each of the sequence of wafers, measuring thicknesses of the wafer before material is deposited on the wafer;

for each of the sequence of wafers, measuring thicknesses of the wafer after material is deposited on the wafer;

for each of the sequence of wafers after the first wafer of the sequence, configuring the parameters for depositing material on the wafer based on the specified deposition pattern, the measured thickness of the current wafer before material is deposited on the current wafer, the measured thickness of the previous wafer in the sequence before material is deposited on the previous wafer, the parameters used for depositing material on the previous wafer, and the measured thicknesses of the previous wafer after material is deposited on the previous wafer.

28. (Original) The method of claim 27 wherein the specified deposition pattern is a flat deposition pattern.

29. (Original) The method of claim 27 wherein the specified deposition pattern is a concave deposition pattern.

30. (Original) The method of claim 27 wherein the specified deposition pattern is a convex deposition pattern.

31. (Original) The method of claim 27 wherein the specified deposition pattern is an arbitrary radial profile.

32. (Original) The method of claim 27 wherein the specified deposition pattern is an arbitrary profile.

33. (Original) The method of claim 27, further comprising, for a second deposition chamber:

retrieving a set of offset values characterizing differences between the deposition chamber and the second deposition chamber;

modifying the parameters most recently configured for the deposition chamber in accordance with the retrieved set of offset values to obtain a parameters for the second deposition chamber; and

configuring the second deposition chamber with the obtained parameters for the second deposition chamber.

34. (Original) An apparatus for automatically configuring parameters controlling operation of a deposition chamber to deposit material on each of a sequence of wafers to improve conformity with a specified deposition pattern, comprising:

a pre-deposition measuring subsystem that measures thicknesses of each of the sequence of wafers before material is deposited on the wafer;

a post-deposition measuring subsystem that measures thicknesses of each of the sequence of wafers after material is deposited on the wafer;

a parameter configuration subsystem that configures the parameters for depositing material on each of the sequence of wafers after the first wafer of the sequence based on the specified deposition pattern, the measured thickness of the current wafer before material is deposited on the current wafer, the measured thickness of the previous wafer in the sequence before material is deposited on the previous wafer, the parameters used for depositing material on the previous wafer, and the measured thicknesses of the previous wafer after material is deposited on the previous wafer.

35. (Original) A method in a computing system for constructing a sensitivity matrix usable to adjust currents for a plurality of electrodes in an electroplating chamber to improve plating uniformity, comprising:

for each of a plurality of radii on the plating workpiece, obtaining a plating thickness on the workpiece at that radius when a set of baseline currents are delivered through the electrodes;

for each of the electrodes, for each of a plurality of plating workpiece radii, obtaining a plating thickness on the workpiece at that radius when the baseline currents are perturbed for that electrode; and

constructing a matrix, a first dimension of the matrix corresponding to the plurality of electrodes, a second dimension of the matrix corresponding to the plurality of radii, each entry for a particular electrode and a particular radius being determined by subtracting the thickness at that radius when the baseline currents are delivered through the electrodes from the thickness at that radius when the baseline currents are perturbed for that electrode, then dividing by the magnitude by which that the current for that electrode was perturbed from its baseline current.

36. (Original) The method of claim 35 wherein the current for each electrode is perturbed by approximately +.05 amps.

37. (Original) The method of claim 35 wherein the current for each electrode is perturbed by a factor in the range between 1% and 10%.

38. (Original) The method of claim 35 wherein the obtained thicknesses are obtained by executing a simulation of the operation of the electroplating chamber based upon a mathematical model of the electroplating chamber.

39. (Original) The method of claim 35 wherein the obtained thicknesses are obtained by measuring workpieces plated in the electroplating chamber.

40. (Original) The method of claim 35, further comprising repeating the method to produce additional sensitivity matrices for a variety of different conditions.

41. (Original) The method of claim 35, further comprising using the constructed sensitivity matrix to modify for use in plating a second workpiece currents used

to plate a first workpiece, such that the modified currents cause the second workpiece to be plated more uniformly than the first workpiece.

42. (Original) One or more computer memories collectively containing a sensitivity matrix data structure relating to a deposition chamber having a plurality of deposition initiators for depositing material on a workpiece having selected radii, a control parameter being associated with each of the deposition initiators, the data structure comprising a plurality of quantitative entries, each of the entries predicting, for a given change in the control parameter associated with a given deposition initiator, the expected change in deposited material thickness at a given radius,
such that the contents of the data structure may be used to determine revised deposition initiator parameters for better conforming deposited material thicknesses to a target profile for deposited material thicknesses.

43. (Original) The computer memories of claim 42 wherein the deposition initiators are electrodes, and wherein the control parameters associated with the deposition initiators are currents delivered through the electrodes.

44. (Original) The computer memories of claim 42 wherein the sensitivity matrix data structure is a Jacobian sensitivity matrix.

45. (Original) The computer memories of claim 42 wherein the computer memories contain multiple sensitivity matrix data structures, each adapted to a different set of conditions.

46-59. (Cancelled)

60. (Original) A method in a computing system for controlling an electroplating process having multiple steps in an electroplating chamber having a plurality of electrodes, comprising:

for each electrode, determining the net plating charge delivered through the electrode during a first plating cycle to plate a first workpiece by summing the plating charges delivered through the electrode in each step of the process;

comparing a plating profile achieved in plating the first workpiece to a target plating profile to identify deviations between the achieved plating profile and the target plating profile;

determining new net plating charges for each electrode selected to reduce the identified deviations in a second workpiece;

for each new plating charge, distributing the new net plating charge across the steps of the process;

using the distributed new net plating charges to determine a current for each electrode for each step of the process; and

conducting a second plating cycle to plate a second workpiece, using the currents determined for each electrode for each step.

61. (Original) The method of claim 60 wherein the new net plating charges are distributed uniformly across all of the steps of the process.

62. (Original) The method of claim 60 wherein the new net plating charges are distributed across the steps of the process by distributing differences between the new net plating charge and the delivered net plating charge to a single step of the process.

63. (Original) The method of claim 60 wherein the distributing includes distributing the new net plating charges to each of two or more phases of a selected one of the steps of the process.

64. (Original) The method of step 60, further comprising repeating the method to further reduce deviations between the achieved plating profile and the target plating profile.

65. (Original) The method of step 60 wherein a sensitivity matrix is used to determine the new net plating charges.

66. (Original) The method of step 60 wherein a different sensitivity matrix is used to determine a new net plating charge for each step of the process.

67. (Original) A method in a computer system for evaluating a design for an electroplating reactor, comprising:

applying to a set of initial electrode currents a mathematical model embodying the reactor design to determine a first resulting plating profile;

comparing the first resulting plating profile to a target plating profile to obtain a first difference;

applying a sensitivity technique to identify a set of revised electrode currents;

applying the mathematical model to the set of revised electrode currents to determine a second resulting plating profile;

comparing the second resulting plating profile to the target plating profile to obtain a second difference; and

evaluating the design based on the obtained second difference.

68. (Currently Amended) An apparatus for automatically selecting parameters for using in controlling operation of a deposition chamber to deposit material on a selected wafer to optimize conformity with a specified deposition pattern, comprising:

a measurement receiving subsystem that receives:

pre-deposition thicknesses of the selected wafer before material is deposited on the wafer;

post-deposition thicknesses of an already-deposited wafer after material is deposited on the already-deposited wafer; and

pre-deposition thicknesses of the already-deposited wafer before material is deposited on the wafer; ~~and~~

a parameter selection subsystem that selects the parameters to be used to deposit material on the selected wafer based on the specified deposition pattern, the pre-deposition thicknesses of the selected wafer, the pre-deposition thicknesses of the already-deposited wafer, parameters used for depositing material on the already-deposited wafer, and the post-deposition thicknesses of the already-deposited wafer; and

a memory containing a sensitivity matrix used by the parameter selection subsystem in selecting parameters to be used to deposit material on the selected wafer.

69. (Original) The apparatus of claim 68, further comprising a deposition chamber for depositing material on the selected wafer using the parameters selected by the parameter selection subsystem.

70. (Cancelled)

71. (Currently Amended) A method in a computing system for automatically configuring parameters usable to control operation of a deposition chamber to deposit material on a selected wafer to optimize conformity with a specified deposition pattern, comprising:

receiving pre-deposition thicknesses of the selected wafer before material is deposited on the wafer;

receiving post-deposition thicknesses of an already-deposited wafer after material is deposited on the already-deposited wafer; ~~and~~

receiving pre-deposition thicknesses of the already-deposited wafer before material is deposited on the wafer; and

selecting the parameters to be used to deposit material on the selected wafer based on the specified deposition pattern, the pre-deposition thicknesses of the selected wafer, the pre-deposition thicknesses of the already-deposited wafer, parameters used for depositing material on the already-deposited wafer, and the post-deposition thicknesses of the already-deposited wafer.

72. (Original) The method of claim 71, further comprising controlling a deposition chamber to deposit material on the selected wafer using the selected parameters.

73. (Original) The method of claim 71 wherein a sensitivity matrix is used in selecting parameters to be used to deposit material on the selected wafer.

74-87. (Cancelled)

88. (Original) A method for constructing a library of deposition process parameter sets for use in controlling a material deposition tool in which multiple control points are controlled in order to control material deposition, comprising:

receiving a plurality of recipes, each recipe identifying a different set of characteristics to be used in performing a deposition process with the tool;

for each received recipe,

operating the tool in accordance with the recipe, and controlling each of the control points in accordance with an initial parameter set, to deposit a test workpiece;

evaluating the deposited test workpiece;

identifying deviations between the evaluation of the deposited test workpiece and a target deposition profile;

modifying the initial parameter set in a manner projected to reduce the identified deviations; and

storing the modified initial parameter set in a manner that associates it with the received recipe.

89. (Original) The method of claim 88, further comprising:

selecting one of the plurality of recipes;

in response to the recipe selection, retrieving the parameter set associated with the selected recipe; and

operating the tool in accordance with the selected recipe, and controlling each of the control points in accordance with the retrieved parameter set, to deposit a workpiece.

90. (Original) The method of claim 88 wherein the control points of the deposition tool are electrodes, and wherein each initial and modified parameter set specifies a manner of controlling each of the electrodes.

91-93. (Cancelled)

94. (Original) One or more computer memories collectively containing an electroplating current data structure, the data structure comprising information specifying, for each of a plurality of seed layer resistivity ranges, a set of currents to be delivered to a group of electrodes in order to electroplate a workpiece having a seed layer whose resistivity falls within the range.

95. (Original) The computer memories of claim 94 wherein the sets of currents specified by information in the data structure are experimentally determined under computer control.

96. (Currently Amended) A method in a computing system for automatically configuring parameters usable to control operation of a reaction chamber to

electropolish a selected wafer to optimize conformity with a specified electropolishing pattern, comprising:

receiving pre-polishing thicknesses of the selected wafer before the selected wafer is polished;

receiving post-polishing thicknesses of an already-polished wafer after the already-polished wafer is polished; ~~and~~

receiving pre-polishing thicknesses of the already-polished wafer before the already-polished wafer is polished; and

selecting the parameters to be used to polish the selected wafer based on the specified polishing pattern, the pre-polishing thicknesses of the selected wafer, the pre-polishing thicknesses of the already-polished wafer, parameters used for polishing the already-polished wafer, and the post-polishing thicknesses of the already-polished wafer.

97-98. (Cancelled)

99. (Original) A method in a computing system for electroplating a microelectronic workpiece, comprising:

receiving data representing a profile of a seed layer that has been applied to the workpiece;

identifying deficiencies in the seed layer based upon the profile of the seed layer represented by the received data;

determining a set of control parameters for plating the workpiece in a manner that compensates for the identified deficiencies in the seed layer; and

communicating the determined set of control parameters to a plating tool for use in plating the workpiece.

100. (Original) The method of claim 99 wherein the determined set of control parameters is, for each of a plurality of electrodes of the plating tool, one or more current levels to be delivered through the electrode.

101. (New) The method of claim 27, further comprising, during deposition of material on a distinguished wafer of the sequence after the first wafer of the sequence, altering the parameters for depositing material on the distinguished wafer.